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(54) **ELECTRIC PROPULSION UNIT AND TORQUE TRANSMISSION GROUP FOR AN ELECTRIC SCOOTER AND CORRESPONDING SCOOTER**

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USPC 180/220
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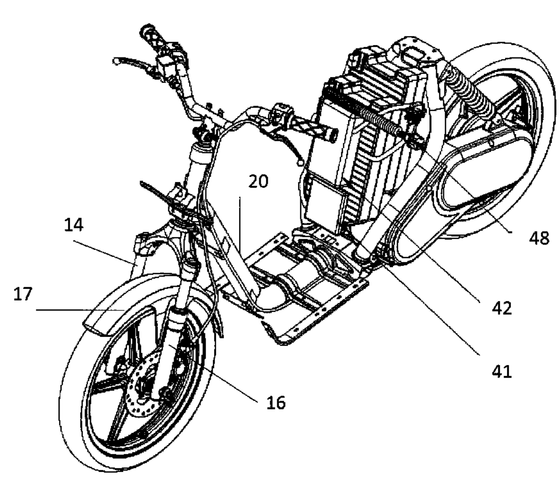
(57) **ABSTRACT**

The invention relates to an electric propulsion unit (**10**) and torque transmission group (**11**) for operating the rear wheel (**13**) of an electric scooter (**1**) with body (**2**) of the step-through type and with upright sitting portion (**6**). The electric propulsion unit (**10**) comprises at least one synchronous electric motor (**30**) of the type comprising internal stator (**32**) and external rotor (**29**) with a cup-shaped form rotating on a fixed shaft (**33**) rigid with the stator (**32**); the motor is installed in a barycentric position substantially at the base of the upright sitting portion (**6**) with the fixed shaft (**33**) transverse to the longitudinal axis (X-X) of the scooter (**2**), and the transmission group (**11**) comprises at least one first and one second reduction stage (**24**, **26**).

10 Claims, 12 Drawing Sheets



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B60K 1/04	(2006.01)
B62M 9/02	(2006.01)
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B60L 11/18	(2006.01)
B60L 15/20	(2006.01)

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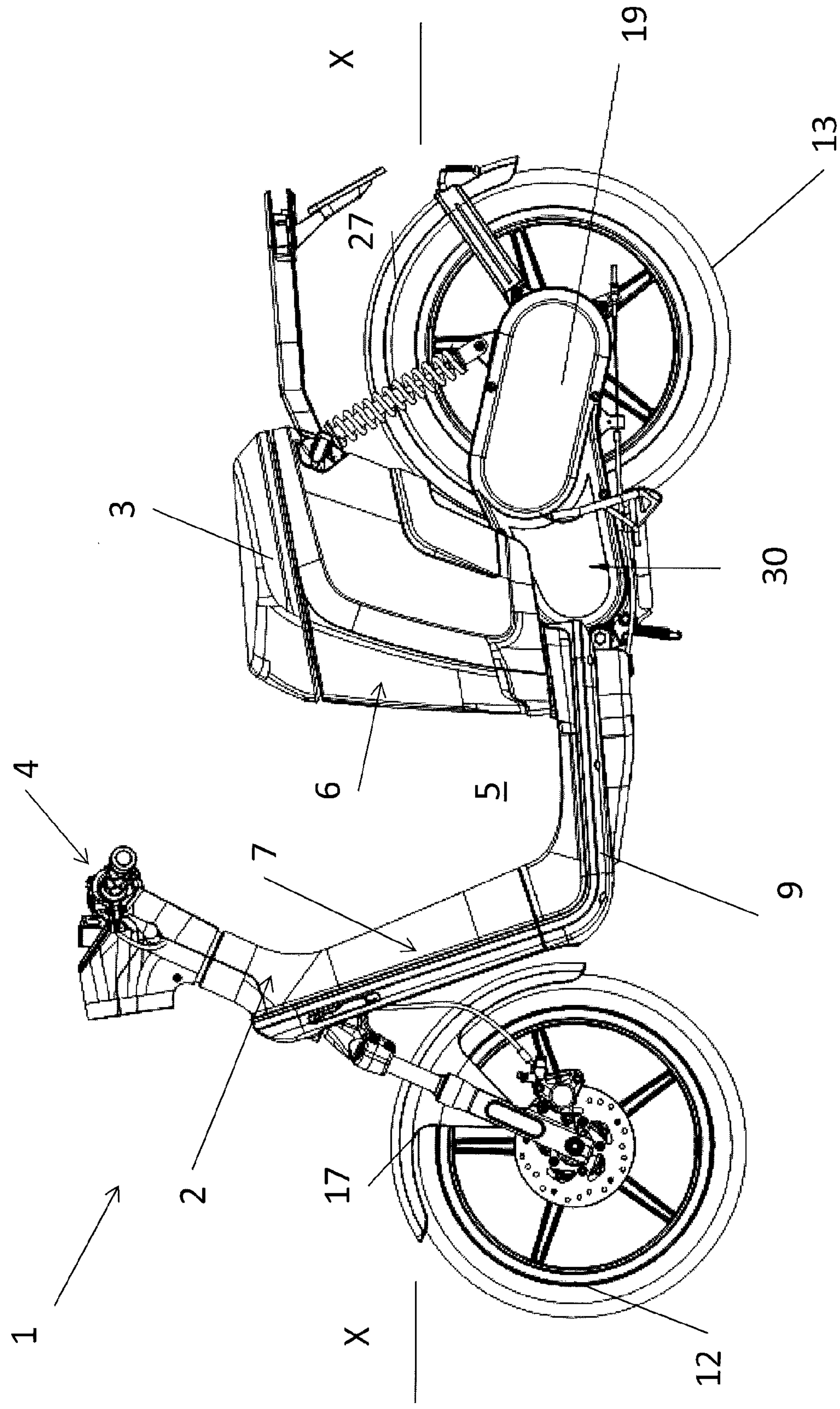


FIG. 1

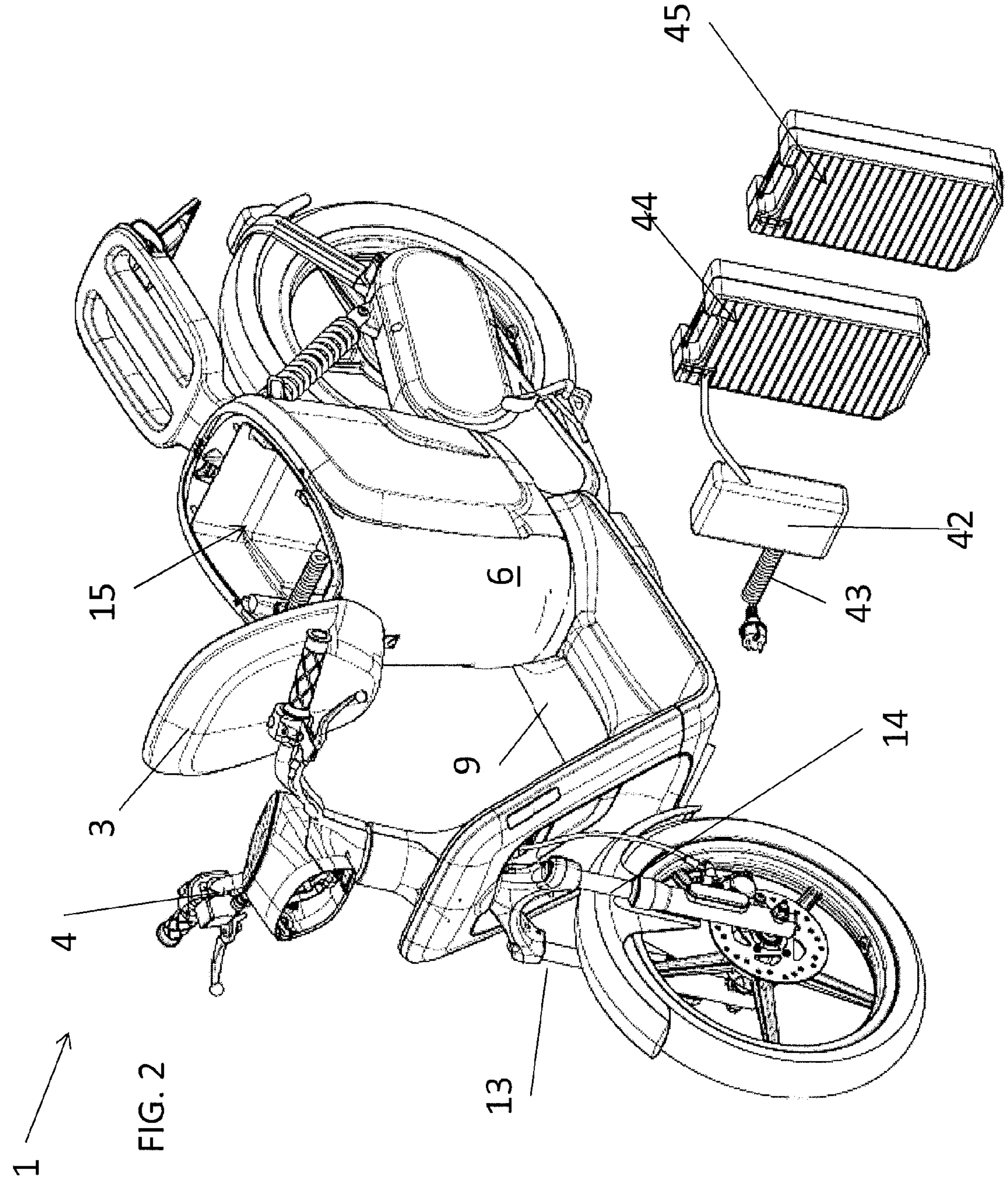


FIG. 2

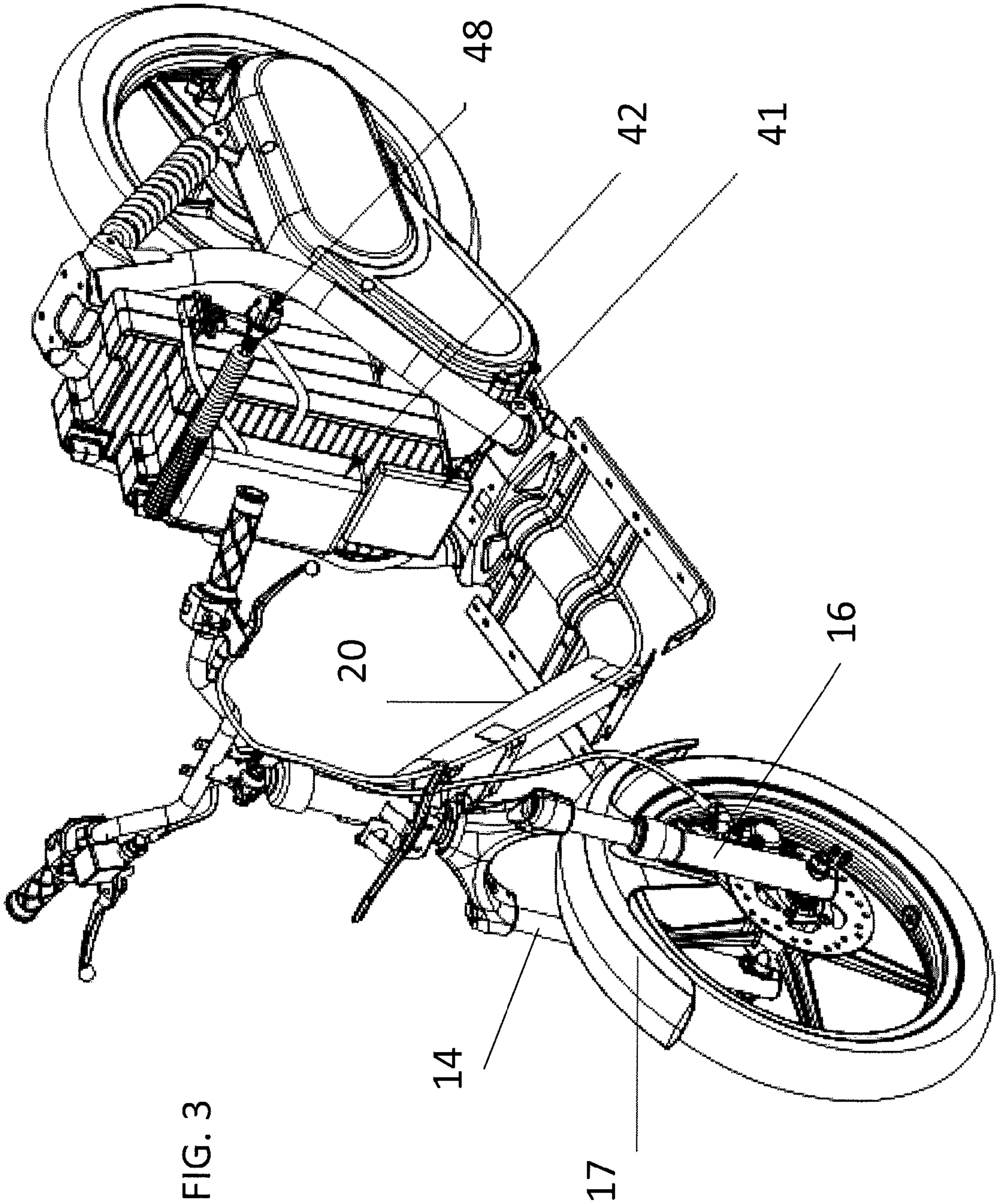
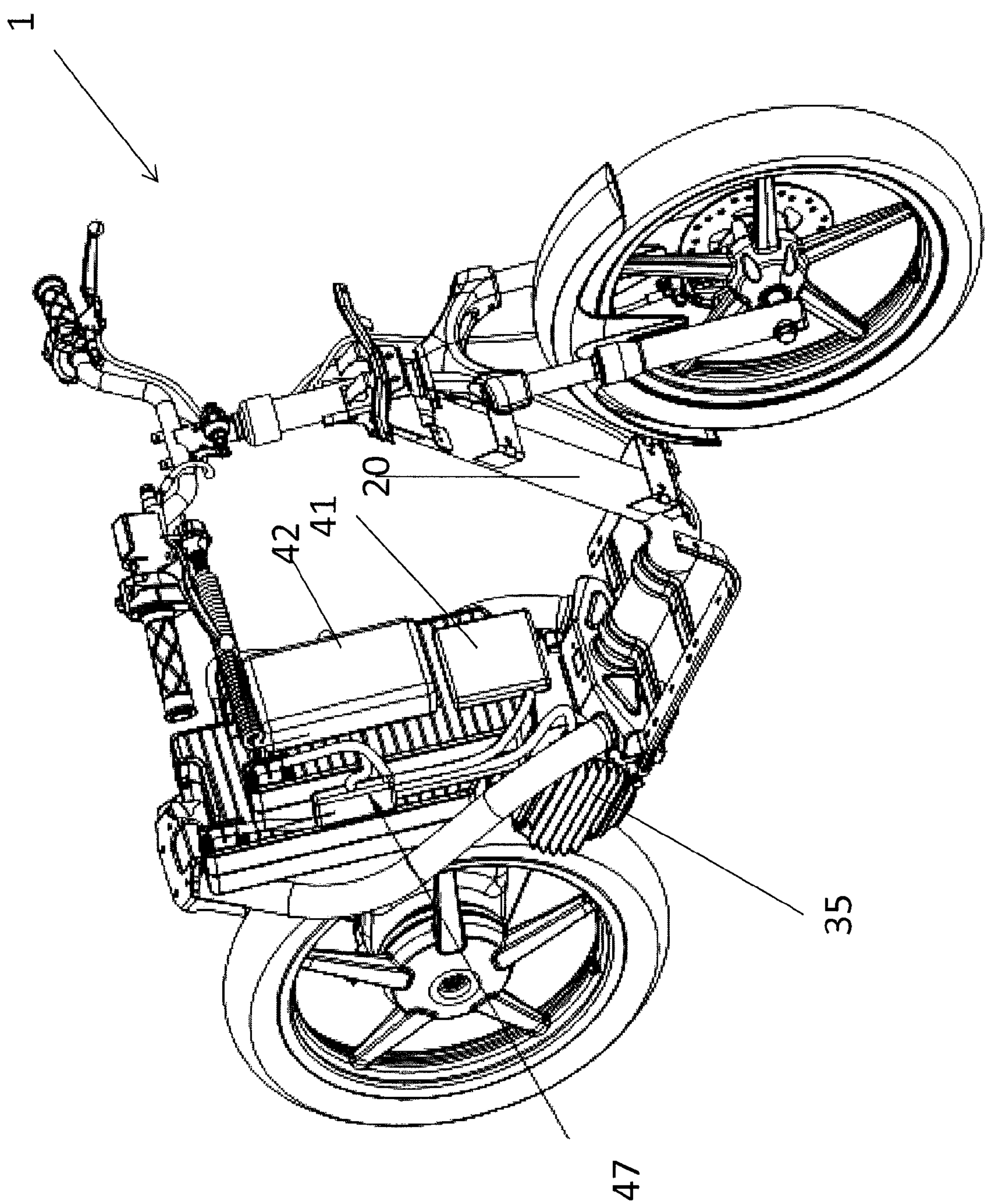


FIG. 3

FIG. 4



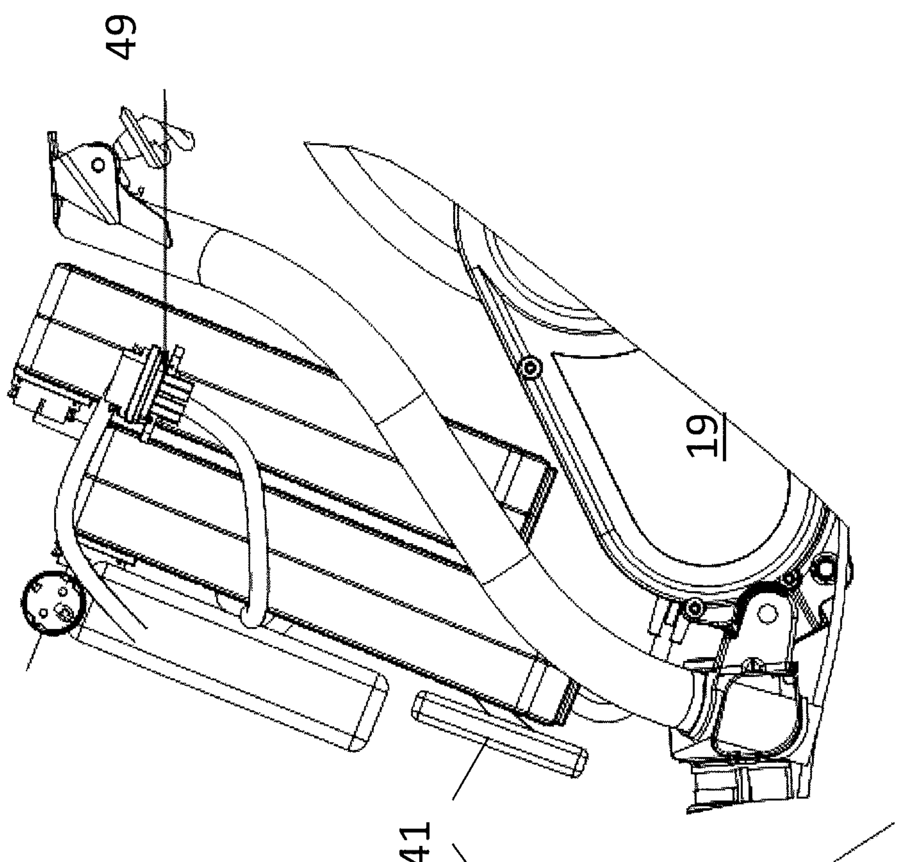


FIG. 6

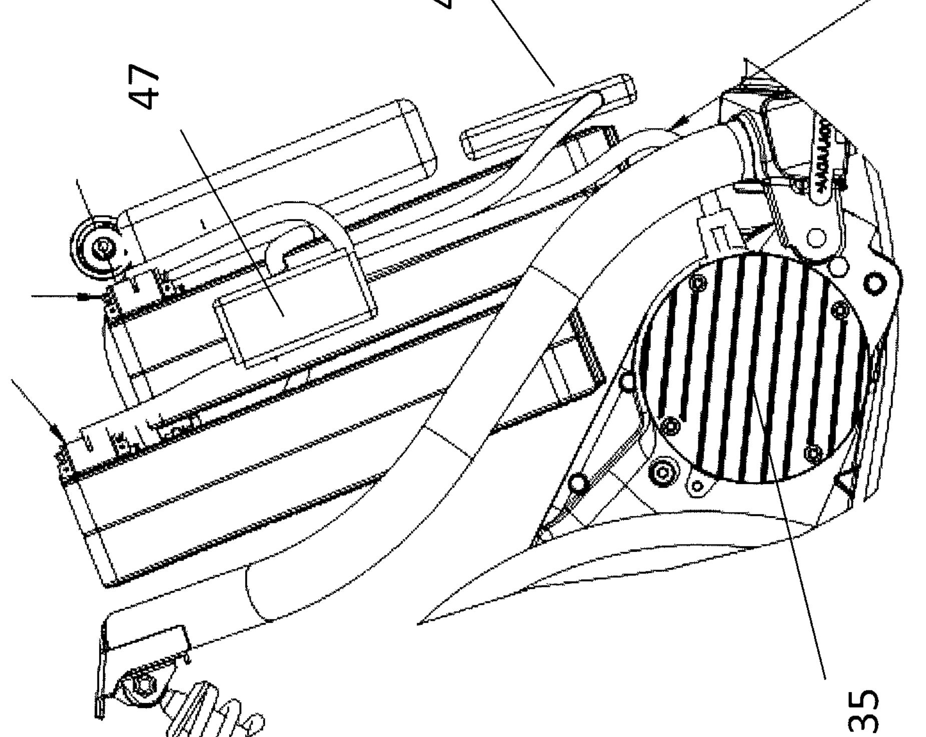


FIG. 5

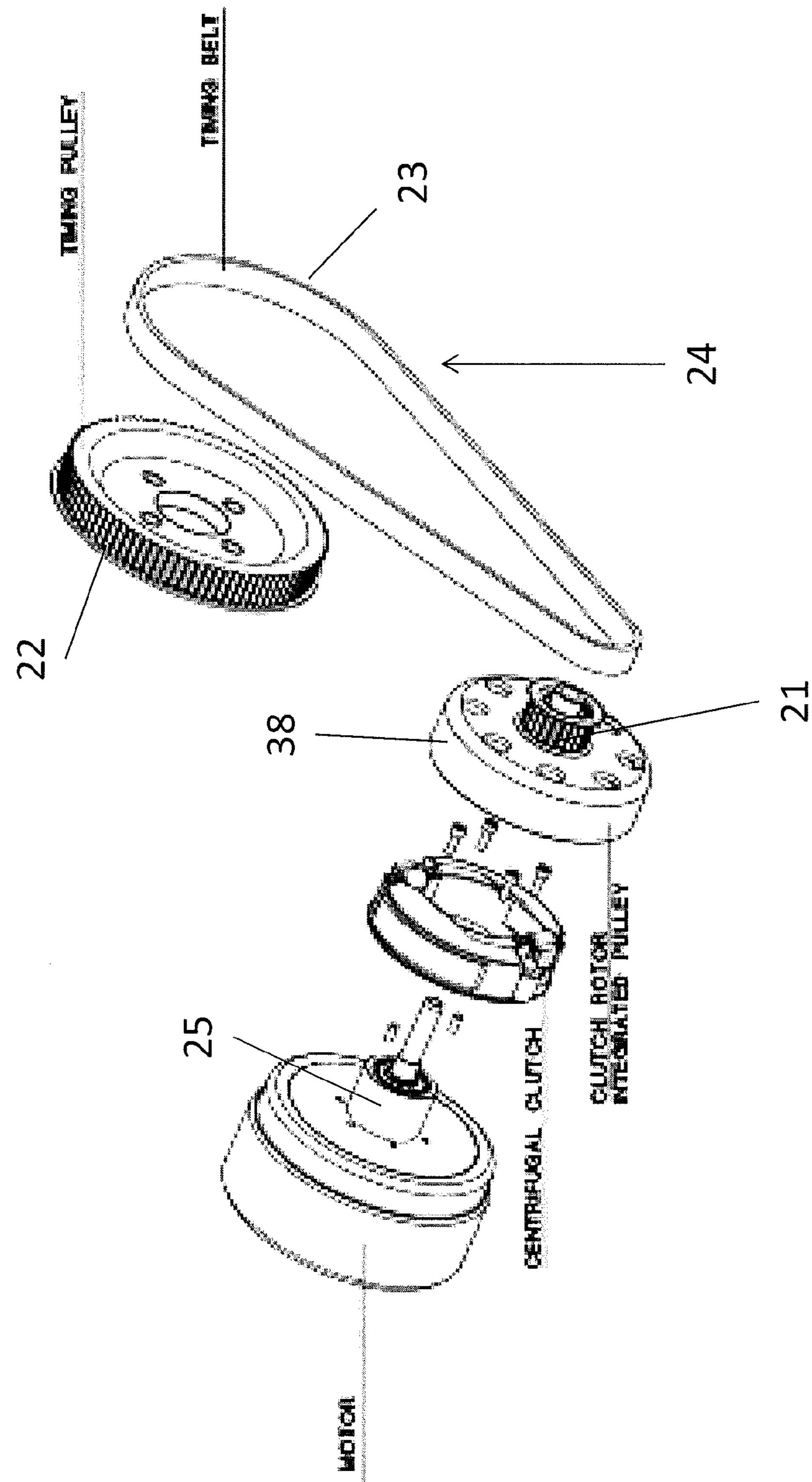
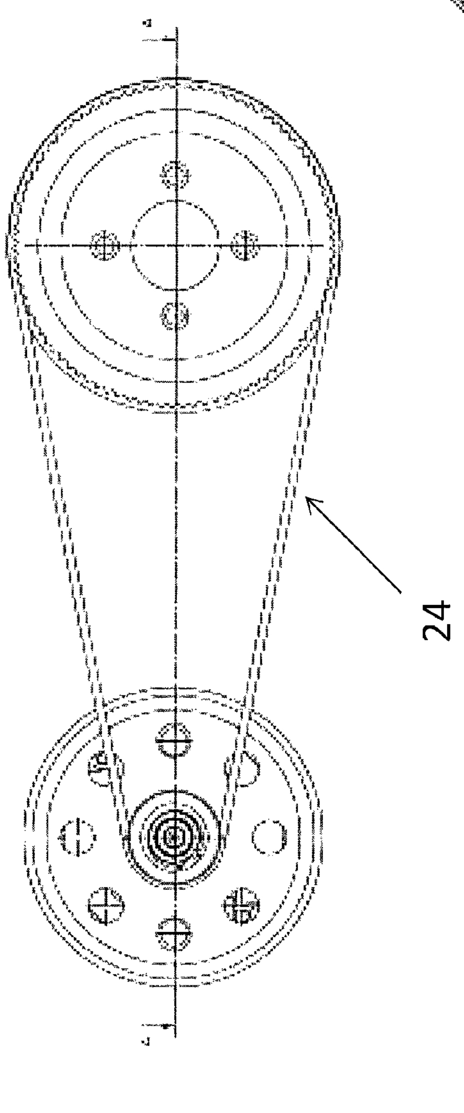

TIMING PULLEY
TIMING BELT
23
24
22
38
21
CLUTCH ROTOR
INTEGRATED PULLEY
CENTRIFUGAL CLUTCH
25
30
BRUSHLESS MOTOR

FIG. 7

FIG. 8



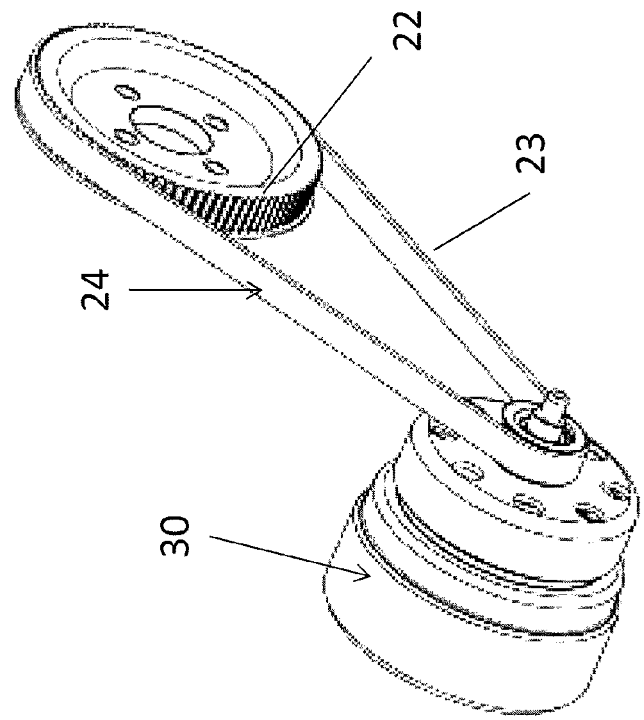
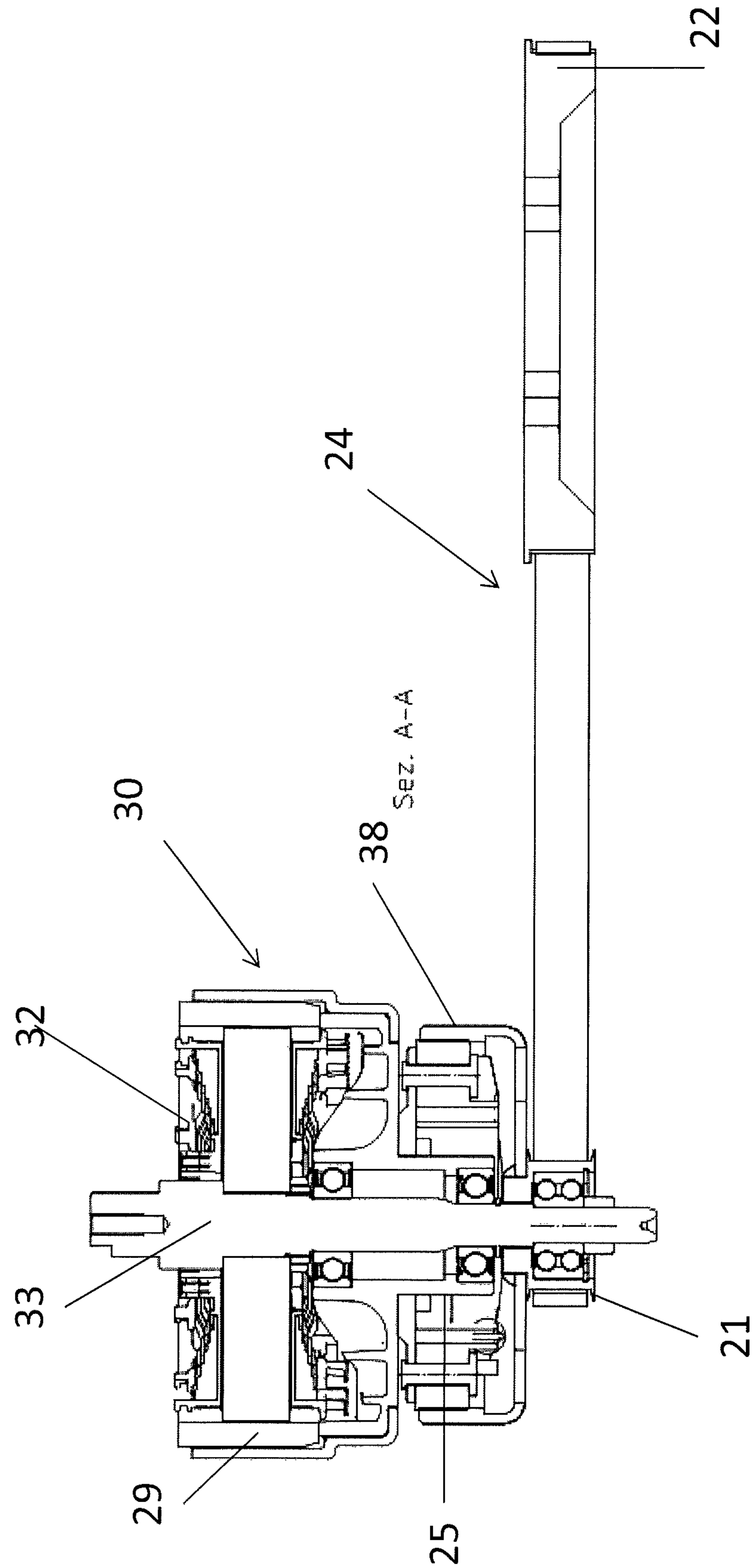


FIG. 9

FIG. 10



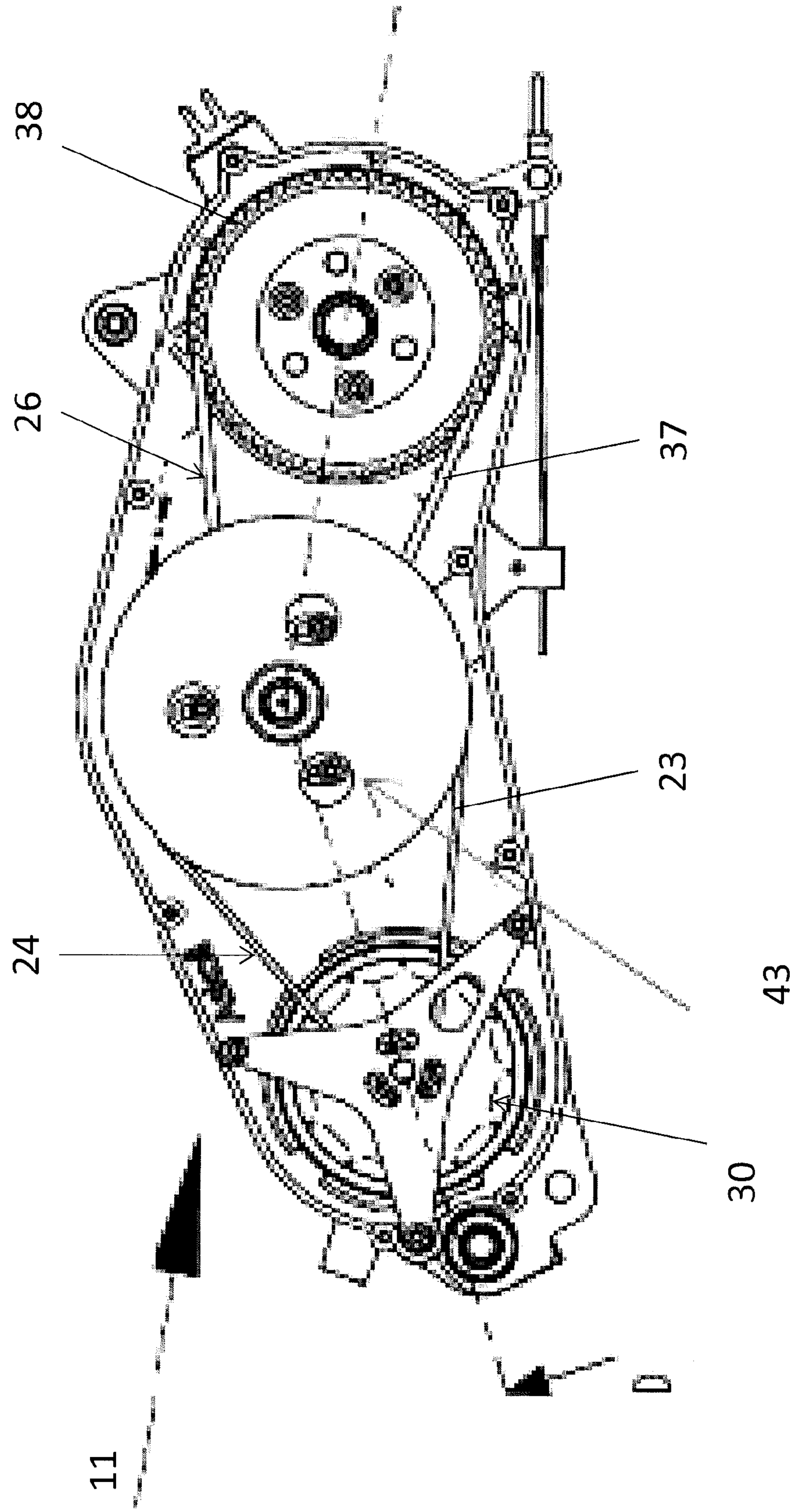


FIG. 11

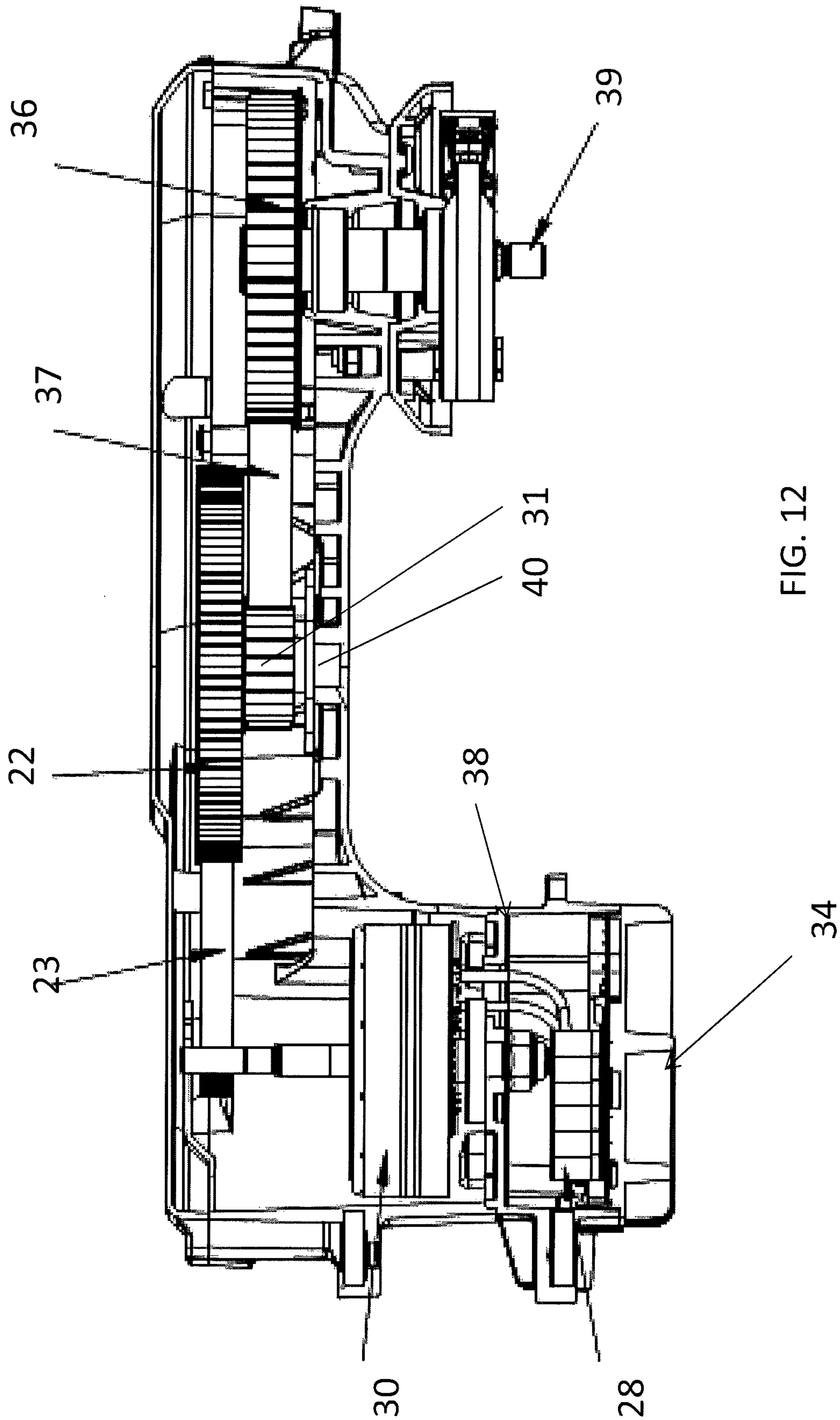


FIG. 12

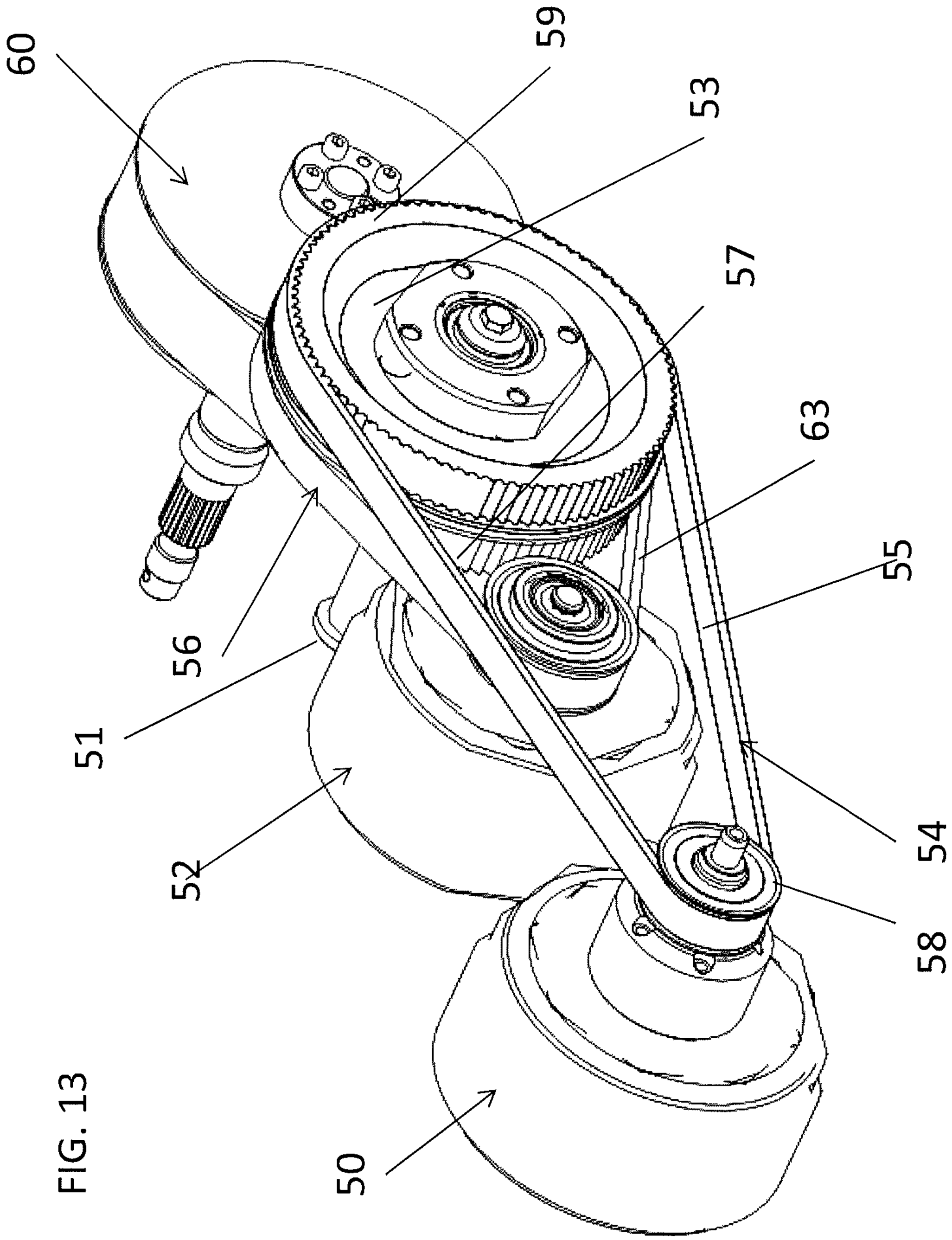
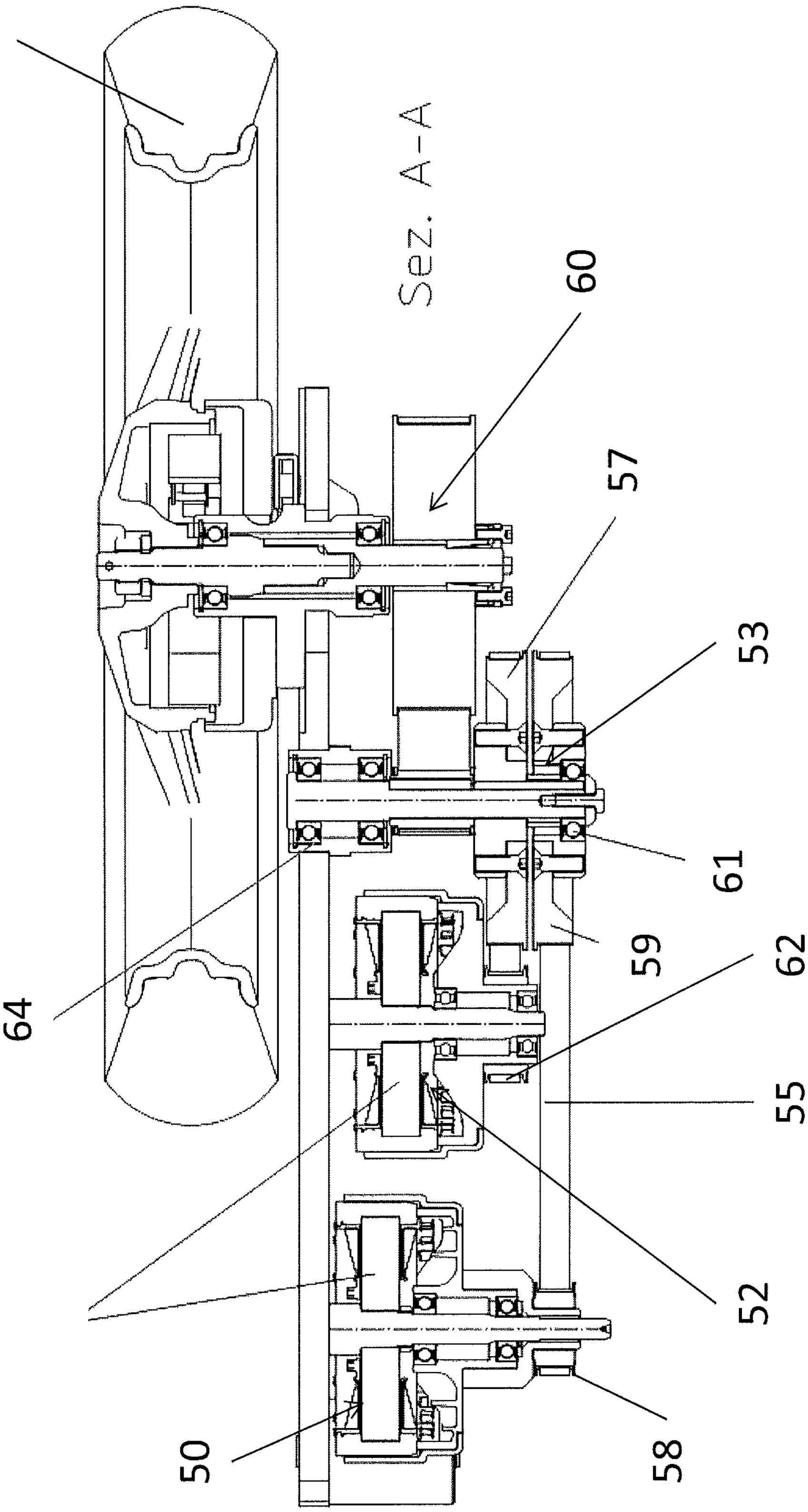


FIG. 13

FIG. 14



ELECTRIC PROPULSION UNIT AND TORQUE TRANSMISSION GROUP FOR AN ELECTRIC SCOOTER AND CORRESPONDING SCOOTER

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority to European Patent Application No. 14425036.2, filed Mar. 20, 2014, the entirety of which is incorporated herein by reference.

FIELD OF APPLICATION

The present invention relates to an electric propulsion unit and torque transmission group for an electric scooter and to a corresponding scooter on which said propulsion unit is installed.

More particularly, the invention relates to an electric propulsion unit and torque transmission group for operating the rear wheel of an electric scooter with a body of the step-through type and with an upright sitting portion, said electric propulsion unit comprising at least one synchronous electric motor.

PRIOR ART

For some years now, following a growing awareness with regard to environmental issues, so-called “zero emission vehicles” (ZEV) have been developed and become more widespread. These vehicles in fact are characterized by the fact that they release practically zero polluting emissions into the atmosphere.

In particular the most common zero emission vehicles are electrically propelled transportation means or electric vehicles.

The characteristic feature of these electric vehicles is that they have an electric motor which uses as energy source the energy stored in one or more rechargeable batteries. It is widely known that one of the main problems preventing the widespread use of electrically propelled vehicles is the poor efficiency of energy storage and the electric-battery recharging cycles.

Among all electric vehicles, those which are less affected by the drawbacks associated with use of the batteries and therefore autonomy, are scooters since they are used for relatively short distances, often only in an urban environment, they have a balanced weight/power ratio and are able to transport a battery set or pack suitable for the use and autonomy which the scooter must have.

Electric scooters are very silent, do not produce any polluting emissions and ensure several tens of kilometers of autonomy, even up to 60-80 km in the case of the most advanced models, in particular those equipped with lithium batteries.

These electric scooters are currently designed for specific market sectors. For example, a vast range of three-wheel or four-wheel electric scooters, operating at low or very low speeds and designed mainly to meet the mobility needs of old and disabled people, is currently available on the market.

Another different type of scooter consists instead of scooters, similar to a motorcycle, which are capable of reaching high speeds, but are extremely costly and sophisticated and intended exclusively for an elite of users who are particularly sensitive to ecological issues, but are not worried by the high purchase and maintenance costs.

An intermediate range of two-wheel scooters which are lighter and more manageable has instead been developed and has become quite popular for performing routine daily duties in the public sector, such as mail distribution.

While meeting the various different requirements of users as briefly described above, these electric scooters have not yet become widespread mainly because their production is still hindered by technical problems which have not yet been solved. In addition to the aforementioned problems associated with the battery pack, there is also the problem of the electric motor which drives the scooter and the difficulties of producing at a competitive cost motors and transmissions for scooters which are able to ensure a good response to operating commands in all riding conditions along winding or undulating roads.

Nowadays, for the private consumer increasingly sensitive to ecological issues, the greatest obstacle to acquiring an electric scooter is the purchase cost in relation to the performance features and autonomy which can be achieved.

Therefore the main factor preventing the large-scale distribution of electric scooters is the substantial limitation of the potential target users.

Another factor hindering the spread of electric scooters is their typical poor handling, the poor initial acceleration on hills and the need for frequent recharging of the batteries.

In the light of these problems an essential need is to develop the motor and transmission group in an attempt to render it more efficient, achieve a lower energy consumption during initial acceleration and overall obtain a greater autonomy of use, all of which at a low cost.

Hitherto, the known art has attempted to provide a solution to these problems by attempting for example to optimize each of the component parts of the electric scooter, namely by using the best electric motor possible, the best transmission and the best batteries. The result has been precisely that of providing scooters which are extremely costly and substantially without a market.

Moreover, more recently it has been noted that the technology would appear to be oriented towards the use of permanent-magnet synchronous motors as propulsion units for this type of scooter, but paradoxically the use of such motors has diminished owing to the dramatic increase in the cost of rare earths which are conventionally used for the production of these motors.

In order to maintain competitive prices, manufacturers have thus been obliged to resort to alternative heavier and larger-volume solutions, such as asynchronous motors or excited-rotor synchronous motors, to the detriment of the compactness and the electric power consumption of the motor unit.

The technical problem underlying the present invention is that of devising a motor unit and transmission group for electric scooters having structural and functional characteristics such as to be able to overcome the limitations and drawbacks of the solutions proposed by the prior art and ensure a particularly compact configuration, a satisfactory transmission ratio and a lower electric power consumption, while reducing at the same time the production costs for the manufacture of said group.

SUMMARY OF THE INVENTION

The proposed solution forming the basis of the present invention has been that of developing in synergism the electric motor unit and torque transmission group so as to provide an innovative solution designed expressly for the traction of the electric scooter, i.e. avoiding using already proven solutions, but focusing on the need for mobility, autonomy and reliability which this type of electric vehicle must have.

The technical problem has been solved by an electric propulsion unit and torque transmission group for operating the rear wheel of an electric scooter with a body of the step-through type and with upright sitting portion, said electric propulsion unit comprising at least one synchronous electric motor, characterized in that said synchronous electric motor is of the type comprising internal stator and external rotor with a cup-shaped form rotating on a fixed shaft rigidly connected to the stator, the motor being installed in a barycentric position substantially at the base of the upright sitting portion with the fixed shaft transverse to the longitudinal axis of the scooter, and in that said transmission group comprises at least one first and one second reduction stage.

Advantageously, said at least one first and second reduction stages are formed with a belt-and-pulley transmission. Moreover, the transmission is formed with toothed pulleys and belts.

It is envisaged providing a housing containing said transmission group and also a support sliding inside said housing for an intermediate shaft inserted between said first and second reduction stages, so as to allow relative tensioning of the transmission belts.

A heat dissipator forming an axial extension of the fixed drive shaft is associated with the stator of the electric motor.

The synchronous motor is of the brushless type driven by means of an inverter.

A compartment for housing batteries is also provided in the upright sitting portion. At least two structurally independent battery packs consisting of rechargeable batteries are housed inside said compartment.

The batteries are removable and provided with a battery charger and power plug connector for rapid connection to an electric power supply network.

Moreover, each battery pack is individually removable so as to allow independent external recharging.

In a variation of embodiment the propulsion unit comprises a second synchronous electric motor which can be selectively coupled to the transmission group by means of free wheel mechanism.

The features and advantages of the electric propulsion unit and torque transmission group according to the present invention will become clear from the description, provided hereinbelow, of a preferred example of embodiment provided by way of a non-limiting example with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a vertical and side elevation view of an electric scooter provided in accordance with the present invention;

FIG. **2** shows a perspective view of the electric scooter according to FIG. **1** in which a compartment for housing the electric batteries underneath the seat is indicated;

FIG. **3** shows a perspective view of the scooter according to FIG. **1**, without bodywork so that the inside of the compartment shown in FIG. **2** may be seen;

FIG. **4** shows a further perspective view of the scooter according to FIG. **3** viewed from another viewing side;

FIGS. **5** and **6** are respective and opposite side views of a detail of the central portion without fairing of the scooter according to the invention;

FIG. **7** shows an exploded perspective view of a portion of the torque transmission group of the scooter according to the invention;

FIG. **8** shows a front view of the portion of the transmission group according to FIG. **7** connected to the electric propulsion group;

FIG. **9** shows a perspective view of the portion according to FIG. **7** of the torque transmission group of the scooter according to the invention in the assembled configuration;

FIG. **10** shows a horizontally sectioned view along the line A-A of FIG. **8**;

FIG. **11** shows a front view of the torque transmission group as a whole;

FIG. **12** shows a top plan view of the electric propulsion unit and torque transmission group for the scooter according to the present invention;

FIG. **13** shows a perspective view of a variation of embodiment of the electric propulsion unit and torque transmission group according to the invention;

FIG. **14** shows a cross-sectional view of the variation of embodiment according to FIG. **13**.

DETAILED DESCRIPTION

With reference to these drawings, and in particular the example of FIG. **1**, the reference number **1** denotes overall and in schematic form an electrically propelled vehicle which is designed in accordance with the present invention and which will be referred to below as a motor scooter or electric scooter.

In the preferred embodiment described here by way of a non-limiting example the electrically propelled vehicle is a two-wheel scooter with a weight, power and maximum speed which is in line with that of conventional motor scooters. By of way of a guide, the electric scooter according to the present invention may have a weight of less then 60 kg, a power of up to 2 kW and a maximum speed of less than 45 km/h, such as to be comparable under Italian law to a motor scooter or a lightweight motorcycle.

The vehicle disclosed herewith comprises a frame or body **2** of the step-through type, namely the rider gets onto or mounts the scooter by passing through a lowered central part **5** of the body **2** and sits on an upright sitting portion **6** which comprises a seat **3** and grips the front maneuvering handlebars **4**.

The scooter **1** has a support frame **20** on which the body **2** with the central step-through portion **5** is mounted.

A front shield **7** which protects the rider's legs is provided between the handlebars **4** and the central lowered portion **5** of the body **2**. A foot-rest portion **9** which continuously connects the shield **7** to the upright portion **6** of the seat **3** is also provided.

The upright portion **6** is provided with a fairing and conceals an ample compartment **15** underneath the seat for housing electric batteries, which will be described in detail below with reference to FIGS. **2** to **6**.

The electric scooter **1** comprises two wheels **12**, **13** in line along a longitudinal axis X-X of the vehicle.

The front wheel **12** is conventionally mounted idle on a front fork **14**, **16**, while the rear wheel **13** is a driving wheel. The wheels at the top are protected by respective mudguards **17** and **27**.

The scooter is operated by an electric propulsion unit **10** with an associated torque transmission group **11** designed for connection to the rear wheel **13**.

Advantageously, the electric propulsion unit **10** comprises at least one brushless synchronous electric motor **30** of the type with an internal stator **32** and an external rotor **29**. The motor **30** is driven by an inverter which is associated with an electronic board **28** for regulating and controlling operation of the motor.

As mentioned, this electric motor **30** is of the so-called internal stator and external stator type, namely one where the rotor **29** is mounted on the outside of the respective stator **32** on a basket-shaped support housing. The structure of the motor **30** is described for example in European patent No. EP 1,691,470 in the name of the same Applicant.

For completeness of the description it is pointed out that the stator **32** of the motor **30** has a substantially cylindrical configuration and comprises a plurality of pole shoes which are known per se, for example formed by means of a plurality of laminations which are arranged in a pack on top of and in contact with each other and mounted fixed on a central axis.

The internal stator **32** has a plurality of poles defined by packs of radial laminations around which the electric windings are wound. Sintered end elements made of SMC (soft magnetic composites) which form the pole shoes are positioned at the outer end of each of the lamination packs.

The external rotor **29** comprises a main cup-shaped body; the internal surface of the edge of the external rotor **29**, facing the air gap or the synthesis material of the stator, supports a magnetic ring which is made of plastoferrite injected using thermoplastic moulding (injection-moulding) techniques.

The internal stator **32** is keyed onto the respective fixed shaft **33**.

The main cup-shaped body of the external rotor **29**, which surrounds the internal stator **32**, has a bottom surface which is connected to a tubular portion **25** which extends away from the internal stator **32** and is rotatably supported on the fixed shaft **33** by means of bearings.

A radial-expansion centrifugal clutch **38** may be provided rigidly connected to the external rotor **29** on the side where the tubular portion **25** is situated.

The presence of the clutch **38** is optional and it is quite possible to connect directly the tubular portion of the rotor **29** to a first driving pulley **21** forming part of the transmission group **11** which will be described below.

The synchronous electric motor **30** also comprises the electronic control board **28** which is electrically connected to the motor and a heat dissipator **34** associated with the electronic management and control board **28**. The board **28** also contains resident software which controls operation of the electric motor and the torque requirements of the scooter, as will become clear from the description below. A detailed explanation of operation of the driver electronics is however not included in the present description.

The electronic board **28** is known per se, as is also the heat dissipator element **34** which has a lamination-like form with a broad heat-exchange surface area, visible in FIGS. **4** and **5**. According to the present invention, the heat dissipator element **20** is mounted on the stator **5** along an axial extension thereof in a predetermined relationship spaced from it so as to allow the arrangement of the electronic board in between.

Moreover, the electronic control board **28**, associated with the inverter, is supported by the heat dissipator element **34**, on one side of the latter, as shown in FIG. **11**, in order to obtain an electrical connection with a small amount of wiring.

The assembly consisting of motor **30** and dissipator **34** is housed inside an aluminium compartment with a finned cover **35** so as to favour dissipation of the heat.

Advantageously, according to the invention, the synchronous motor **30** is installed in a barycentric position substantially at the base of the upright sitting portion **6** with the shaft **33** of the motor **30** transverse to the longitudinal axis X-X of the scooter **2**.

This arrangement provides the entire structure of the scooter with particular stability and ensures balancing of the weight of the vehicle with a better overall distribution of the weights.

Moreover, in order to increase the power output performance, the motor has been designed with suitable dimensions, optimizing the dimensional ratio between rotor and stator poles. The motor has been designed so as to be modular, i.e. its performance characteristics are associated with its axial length, while its radial dimensions remain unchanged, allowing efficient and low-cost management of the mould used to manufacture the magnet using anisotropic ferrite which is oriented by a magnetic field during the injection-moulding process, this magnetic field being generated by a magnetic circuit which is formed in the mould.

The electric propulsion unit **10** and the corresponding transmission group **11** are enclosed externally by the casing **19** or housing. The front and rear ends of the casing **19** have points for fastening to the frame **20** of the scooter **1**.

The structure of this mechanism will now examined in greater detail.

The torque transmission group **11** which allows the motor **30** to be kinematically connected to the rear wheel **13** comprises two transmission stages **24**, **26** with toothed belts and pulleys.

The casing **19** has a form which extends in a substantially longitudinal direction, inclined with respect to the centre, corresponding to the angled arrangement of the first and second transmission stages **24**, **26**.

Essentially, the stages **24** and **26** constitute two kinematically connected reduction stages where a first reduction stage **24** comprises transmission members which transmit the movement from the rotor **29** to an intermediate shaft and a second reduction stage **26** comprising further transmission members for transmitting the movement from the intermediate shaft to a shaft for driving the rear wheel.

The first stage **24** comprises a belt **23** extending between a first driving pulley **21** rigidly connected to the rotor **29** of the synchronous motor **30** and a first transmission pulley **22** mounted rotatable on an intermediate shaft provided inside a casing or housing **19** containing the transmission group **11**.

A second stage **26** comprises a belt **37** extending between a second driving pulley **31** coaxial with the transmission pulley **22** and a second traction pulley **36** rigidly connected to a traction shaft onto which a hub **39** of the rear wheel **13** is keyed.

The first driving pulley **21** and the second traction pulley **36** have a fixed interaxial distance and the adjustment of the relative tension of the belts **23** and **37** is performed by means of a particular supporting arrangement of the coaxial transmission pulley **22** and driving pulley **31**.

More particularly, the coaxial and central pulleys are supported on a same intermediate shaft which is in turn slidably mounted on a slide **40** having a predetermined freedom of movement through an eyelet-shaped slot in the casing **19** containing the transmission group **11**.

In a variation of embodiment, which is still based on the principles of the present invention, the electric propulsion unit **10** and the torque transmission group **11** are modified so as to increase the power output of the scooter. An example of this variation of embodiment is shown in FIGS. **13** and **14**.

In this variation of embodiment it is envisaged using two permanent-magnet synchronous electric motors **50** and **52**.

The internal structure of the motors **50** and **52** corresponds to that already described above with reference to the synchronous motor **30**.

The variant with two motors has a free wheel **53** with a two-stage belt transmission. This allows the use of either one of the two motors, which are again driven by an inverter.

Advantageously, depending on the power required, for example when starting or on an uphill slope, it is possible to operate both the motors **50**, **52**, while in normal conditions of use, such as on flat ground at a constant speed, it is possible to operate only one motor, saving energy.

More particularly, in a similar manner to the first example of embodiment, the transmission group **11** of this alternative embodiment comprises a first belt-and-pulley reduction stage **54** in which a first driving pulley **58**, which is rigidly connected to the rotor of the first motor **50**, is kinematically connected to a pulley **59** mounted on the free wheel **53**, via a toothed belt **55**. The free wheel **53** is supported on a spindle **51** by means of bearings **61**.

This first reduction stage **54** has a corresponding second belt-and-pulley reduction stage **56** in which a second driving pulley **62**, rigidly connected to the rotor of the second motor **52**, is kinematically connected to a second driven pulley **57** via a toothed belt **63**. Only the second motor **52** is always connected, while the first motor **50** intervenes depending on the torque demand requirements.

The free wheel **53** and the driven pulley **57** are coaxial with each other and supported on an intermediate spindle **51** which is advantageously mounted rotatably on the casing **19** containing the transmission group via bearings **64**.

When the scooter is travelling in a straight line and a smaller driving torque and power are required, the motor **50** is switched off by the electronic control system and the free wheel **53** disengages it from the shaft **51**; only the motor **52** which is still engaged is able to supply torque and power sufficient for maintaining the speed set by the user. In more severe conditions, for example when travelling uphill, the motor **50** is switched on automatically when a speed synchronised with the motor **52** is reached, and at the same time the free wheel which rigidly connects it to the shaft **51** is locked. The two motors **50**, **52** are therefore connected together and able to meet the surplus torque and power requirement.

An end stage with a mechanism **60** connects a pulley rigid with the rotatable spindle **51** to the transmission hub of the rear wheel **13**.

The description of the present invention is now completed by the details relating to the battery system which constitutes the electric power source of the scooter **1**.

The scooter **1** is designed to house inside the compartment **15** underneath the seat at least two extractable battery packs **44**, **45**; each pack **44**, **45** has inside it a battery management system (BMS) for managing the battery charge, which is incorporated in an electronic control unit **41** for supervising and controlling operation of the scooter **1**.

In FIGS. **3** and **4** it is possible to see clearly the removable battery packs **44**, **45**, the control unit **41** and an externally accessible connector **48** which protrudes from the outer surface of the fairing of the upright sitting portion **6** and allows a quick-fit connection to the electric power supply network for recharging the batteries kept on the scooter.

An interconnecting element **49**, which can be seen in FIG. **6** and allows the entire battery assembly to be removed from the compartment **15**, is arranged on the electrical connection line between the external connector **48** and the battery packs.

The two battery packs **44**, **45** are, however, structurally independent of each other and also independently removable by means of a connector **47** which is clearly visible in FIG. **5** and allows them to be rapidly connected or disconnected to/from each other.

Moreover, the specially designed compartment **15** in the scooter houses a battery charger **42** with associated cable **43** and mains plug for connection to a conventional mains socket, the entire removable assembly being connected to the aforementioned control unit **41** by means of quick-fit connectors.

The battery charger **42** is obviously provided with a current transformer.

This system allows charging and checking of the state of the batteries, while leaving the packs **44**, **45** interconnected in the scooter; alternatively, however, it is possible to extract manually the battery packs **44**, **45** and connect directly the battery charger **42** also to only one of the battery packs, thus allowing the components to be more easily moved to a location where there is a mains socket which cannot be easily or conveniently reached by the scooter itself.

From the above description it is clear how the scooter according to the present invention may be produced on a large scale at a decidedly low cost, while ensuring an optimum performance along winding or undulating roads and being unusually practical to use.

The invention claimed is:

1. An electric propulsion unit and torque transmission group for operating a rear wheel of an electric scooter with a step-through body and with an upright sitting portion, said electric propulsion unit comprising:

at least one synchronous electric motor, wherein said synchronous electric motor comprises an internal stator and an external rotor with a cup-shaped form rotating on a fixed shaft rigidly connected to the stator,

the motor being designed to be installed in a barycentric position with respect to the scooter substantially at the base of the upright sitting portion with the fixed shaft transverse to the longitudinal axis of the scooter, and

said transmission group comprising at least one first and one second reduction stage formed with a belt-and-pulley transmission,

said transmission group further comprising a support sliding in said casing for an intermediate shaft inserted between said first and second reduction stages, so as to allow relative tensioning of the transmission belts.

2. The electric propulsion unit and torque transmission group according to claim **1**, wherein said transmission is formed with toothed pulleys and belts.

3. The electric propulsion unit and torque transmission group according to claim **1**, wherein a heat dissipator forming an axial extension of the fixed drive shaft is associated with the stator of the electric motor.

4. The electric propulsion unit and torque transmission group according to claim **1**, wherein the synchronous motor is of the brushless type driven by means of an inverter.

5. The electric propulsion unit and torque transmission group according to claim **1**, wherein said electric propulsion unit comprises a battery housing compartment which can be integrated in the upright sitting portion of the scooter.

6. The electric propulsion unit and torque transmission group according to claim **5**, wherein at least two structurally independent rechargeable battery packs are housed inside said compartment.

7. The electric propulsion unit and torque transmission group according to claim **5**, wherein said batteries are removable and provided with battery charger and current plug connector for rapid connection to an electric power supply network.

8. The electric propulsion unit and torque transmission group according to claim **5**, wherein each battery pack is singly removable for external recharging.

9. A two-wheel electric scooter comprising an electric propulsion unit and torque transmission group according to claim **1**.

10. An electric propulsion unit and torque transmission group for operating a rear wheel of an electric scooter with a step-through body and with an upright sitting portion, said electric propulsion unit comprising:

at least one synchronous electric motor, wherein said synchronous electric motor comprises an internal stator and an external rotor with a cup-shaped form rotating on a fixed shaft rigidly connected to the stator, the motor being designed to be installed in a barycentric position with respect to the scooter substantially at the base of the upright sitting portion with the fixed shaft transverse to the longitudinal axis of the scooter, and

said transmission group comprising at least one first and one second reduction stage, wherein

said propulsion group comprises a second synchronous electric motor which can be selectively coupled to the transmission group by means of a mechanism comprising a free wheel.

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